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Spring bird migration phenology in Eilat, Israel

Reuven Yosef[1], Mikhail Markovets[1,2]

1 *International Birding and Research Centre in Eilat, Eilat, Israel* **2** *Zoological Institute RAS, St. Petersburg 199034, Russia*

Corresponding author: *Reuven Yosef* (ryosef@eilatcity.co.il)

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Abstract

Analysis of the mean date of first captures and median arrival dates of spring migration for 34 species of birds at Eilat, Israel, revealed that the earlier a species migrates through Eilat, the greater is the inter-annual variation in the total time of its passage. Birds arrive during spring migration in Eilat in four structured and independent waves. The annual fluctuation in the initial arrival dates (initial capture dates) and median dates (median date of all captures), not including recaptures, did not depend on the length of the migratory route. This implies that migrants crossing the Sahara desert depart from their winter quarters on different Julian days in different years. We suggest that negative correlations between the median date of the spring migration of early and late migrants depends upon the easterly (Hamsin) wind period. Moreover, we believe that the phenology of all birds during spring migration in Eilat is possibly also determined by external factors such as weather conditions on the African continent or global climatic processes in the Northern hemisphere. Orphean Warblers (*Sylvia hortensis*) show a strong negative correlation (r_s = -0.502) of initial capture date with calendar years, whereas other species such as Barred Warbler (*S. nisoria*; r_s = -0.391) and Spotted Flycatcher (*Muscicapa striata*; r_s = -0.398) display an insignificant trend. The Dead Sea Sparrow (*Passer moabiticus*) and Red-Backed Shrike (*Lanius collurio*) are positively correlated regarding initial arrival date and medians of spring migration.

Keywords

Phenology, spring, migration, Eilat

Introduction

During the last two decades in many European countries, spring arrival for numerous bird species has been recorded earlier than during the 1970s. This includes both short-distance migrants and species wintering in Africa (Mason 1995; Sokolov et al.

1998; Sparks 1999; Barrett 2002; Hüppop and Hüppop 2003). The considerable shift in timing of spring migration towards earlier Julian dates has been associated with global warming and climatic change (Bairlein and Winkel 2001; Sokolov 2001; Sparks et al. 2001, 2003; Hüppop and Hüppop 2003). However, the way in which timing of migration actually affects the early stages of spring migration has yet to be defined.

For many migrating species, the Eilat oasis is the first stopover site encountered after crossing the combined geophysical barrier of the Sahel, Sahara and Sinai deserts (Yosef and Tryjanovski 2002a). In some passerines species, e.g., Blackcap *Sylvia atricapilla* (Izhaki and Maitiav 1998), Red-backed and Masked Shrikes (*Lanius collurio, nubicus* resp.; Yosef and Tryjanovski 2002b, c), and Ortolan and Cretzschmar's Bunting (*Emberiza hortulana, caesia* resp.; Yosef and Tryjanovski 2002d, e), a significant interannual variation of the timing of spring migration has been documented.

Here, we present an analysis of the initial arrival (capture) date and median date of migration of 34 avian species in order to better understand if any changes have occurred in the phenology during spring migration for the past 20 years at Eilat.

Materials and methods

From 1984–2003, the International Birding and Research Center in Eilat (IBRCE), Israel (29°33′N, 34°57′E) has trapped and ringed passerines in autumn and in spring. This has resulted in dataset containing information on more than 180.000 individual birds from 272 avian species. In most species, the numbers trapped in spring were higher than in the autumn. The IBRCE ringing program is aimed at three major groups of birds: raptors, waders, and passerines. Because the ringing program during spring began at different times of the month (between 1–15 February), we analyzed data from 15 February only.

In order to analyze the phenology of spring migration, we selected species based on the following criteria: (1) all species were caught in mist nets; (2) no special effort was made to capture individual species, e.g., swallows (*Hirundo* spp.) and wagtails (*Motacilla* spp.) at roost; (3) the species were captured in a minimum of 17 seasons; (4) in sufficient numbers (>20); and (5) the species was not sedentary. Based on these criteria, we included in our final analyses a total of 34 avian species comprising 32 passerine species, Quail (*Coturnix coturnix*) and Wryneck (*Jynx torquilla*) (Table 1).

For all individual birds from all species captured, we calculated the date of initial capture, and the average and median of all captures during the season. The average and median were calculated if the number of birds caught exceeded 20, and excluded all recaptures.

Because of Eilat's unique geographical location on the migratory flyway, our analysis focused on the date of the initial capture and the median date of all captures. It was assumed that the date of initial capture reflected the date of first arrival of the species in that season (Sokolov et al. 1998). The species' median arrival date was considered to be of major importance because the duration of spring migration in Eilat for many species exceeds 3.5 months (Morgan and Shirihai 1997). Further, in

Table 1. Phenology of spring migration of Eurasian bird populations at Eilat, Israel, 1984–2003.

Species	Mean of first capture	SD, days	Median	N, all years
Coturnix coturnix	27.2	19	20.3	971
Jynx torquilla	12.3	8	29.3	332
Anthus trivialis	24.3	8	13.4	1596
Cercotrichas galactotes	10.4	12	3.5	386
Luscinia luscinia	12.4	11	27.4	263
Luscinia megarhynchos	23.3	7	6.4	470
Luscinia svecica	9.2	16	23.3	873
Phoenicurus phoenicurus	19.3	17	31.3	451
Oenanthe hispanica	15.3	17	29.3	200
Oenanthe oenanthe	17.3	10	28.3	707
Locustella luscinioides	26.2	10	18.3	469
Acrocephalus arundinaceus	1.4	17	21.4	315
Acrocephalus schoenobaenus	17.2	11	27.3	2356
Acrocephalus scirpaceus	26.2	10	13.4	3496
Hippolais pallida	11.3	11	27.4	4599
Sylvia atricapilla	3.3	17	23.4	17835
Sylvia borin	22.4	6	12.5	2104
Sylvia communis	26.2	16	28.3	1756
Sylvia curruca	25.2	8	1.4	13691
Sylvia hortensis	20.3	15	28.3	490
Sylvia melanocephala	15.2	11	12.3	737
Sylvia nisoria	28.4	11	13.5	260
Phylloscopus bonelli	11.3	8	26.3	1293
Phylloscopus collybita	11.2	13	18.3	6042
Phylloscopus sibilatrix	11.4	12	21.4	98
Phylloscopus trochilus	25.3	9	22.4	682
Muscicapa striata	22.4	12	3.5	210
Lanius collurio	22.4	12	8.5	217
Lanius nubicus	21.3	8	29.4	1038
Lanius senator	11.3	13	26.3	317
Passer hispaniolensis	11.2	17	26.3	2935
Passer moabiticus	18.2	13	9.3	756
Emberiza caesia	11.3	7	18.3	489
Emberiza hortulana	27.3	6	15.4	2188

many species there are several geographically distinct subspecies, many of which have not been identified to date, which constitute the species population for the season (Morgan and Shirihai 1997).

To corroborate our conjectures, we conducted a correlation analysis between initial and median captures of the 34 species included in our study from 1984–

2003. We also compared dates of initial capture of these species for the two decades from 1984–1993 and from 1994–2003. Standard statistical methods were used to characterize and analyze the data (Sokal and Rohlf 1995). Calculations were made using the STATISTICA v.5 package.

Results

Analysis of the phenology in 34 species at Eilat showed a large inter-annual variation (Table 1). More specifically, early migrants showed large inter-annual variation regarding initial capture date resulting in no statistically significant trends overall (r_s = -0.2547, n = 34, p = 0.146).

Correlation analyses of initial capture date during the past 20 years revealed that in the studied species, change in initial captures ranged from a strong positive influence to results that were statistically insignificant (Table 2). Correlation analyses of median capture dates of the individuals during the past 20 years highlighted groups of species that had similar spring migration timing and phenology (Table 3).

Initial captures of the 34 species confirmed that the first of the spring arrivals are the long-distance migrants, and that they are already present in Eilat by mid-February. Owing to its geophysical position in relation to African winter quarters, one of the important characteristics for Eilat is the simultaneous occurrence of groupings of species (Fig. 1). Combining the results of the correlations analysis of first arrival data and median data of spring migration in Eilat for 20 years showed that there are at least four such waves of arrival.

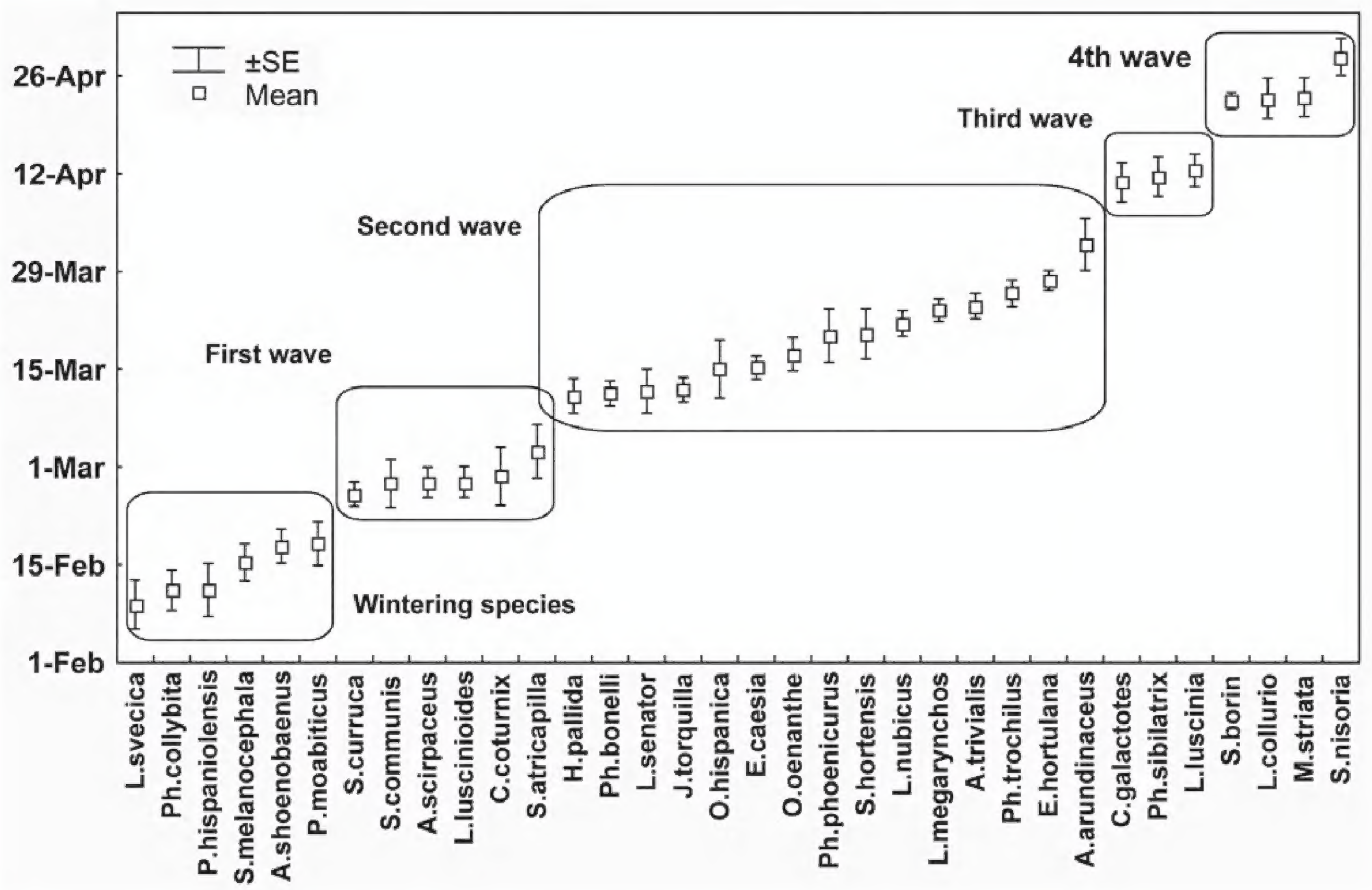

Figure 1. Data of first capture of 34 species of birds in Eilat in 1984–2003.

Table 2. The correlation between first arrival dates of 34 species in the spring in Eilat during 1984–2003. (Spearman's rank correlation 0.701, p <0,001; 0.542, p < 0.01; 0.449, p < 0.05; 0.413, p < 0.1)

Species	***Coturnix coturnix***	***Jynx torquilla***	***Anthus trivialis***	***Cercotrichas galactotes***	***Luscinia luscinia***	***Luscinia megarhynchos***	***Luscinia svecica***	***Phoenicurus phoenicurus***
Emberiza hortulana								
Emberiza caesia								
Passer moabiticus								
Passer hispaniolensis								
Lanius senator								
Lanius nubicus								
Lanius collurio								
Muscicapa striata								
Phylloscopus trochilus								
Phylloscopus sibilatrix								
Phylloscopus collybita								
Phylloscopus bonelli								
Sylvia nisoria								
Sylvia melanocephala								
Sylvia hortensis								
Sylvia curruca								
Sylvia communis								
Sylvia borin								
Sylvia atricapilla								
Hippolais pallida								
Acrocephalus scirpaceus								
A. schoenobaenus								
Acrocephalus arundinaceus								
Locustella luscinioides								
Oenanthe oenanthe								
Oenanthe hispanica								
Phoenicurus phoenicurus								
Luscinia svecica								
Luscinia megarhynchos								**0.618**
Luscinia luscinia								
Cercotrichas galactotes						0.461		
Anthus trivialis				0.466				
Jynx torquilla							0.464	
Coturnix coturnix				0.483			0.509	*0.414*

Species	**Oenanthe hispanica**	**Oenanthe oenanthe**	**Locustella luscinioides**	**A. arundinaceus**	**A. schoenobaenus**	**Acrocephalus scirpaceus**	**Hippolais pallida**	**Sylvia atricapilla**	**Sylvia borin**
Emberiza hortulana									
Emberiza caesia									
Passer moabiticus									
Passer hispaniolensis									
Lanius senator									
Lanius nubicus									
Lanius collurio									
Muscicapa striata									
Phylloscopus trochilus									
Phylloscopus sibilatrix									
Phylloscopus collybita									
Phylloscopus bonelli									
Sylvia nisoria									
Sylvia melanocephala									
Sylvia hortensis									
Sylvia curruca									
Sylvia communis									
Sylvia borin									
Sylvia atricapilla									
Hippolais pallida									
Acrocephalus scirpaceus									
A. schoenobaenus						**0.572**			
Acrocephalus arundinaceus									
Locustella luscinioides					**0.547**	**0.508**			
Oenanthe oenanthe									0.498
Oenanthe hispanica						**0.585**	*0.407*		
Phoenicurus phoenicurus							0.470		
Luscinia svecica					0.445				
Luscinia megarhynchos							*0.413*		
Luscinia luscinia									
Cercotrichas galactotes				**0.556**					
Anthus trivialis		0.504	0.449						
Jynx torquilla				0.440	0.550				
Coturnix coturnix			*0.424*	0.500	**<u>0.688</u>**	**0.588**			

Species	**Sylvia communis**	**Sylvia curruca**	**Sylvia hortensis**	**Sylvia melanocephala**	**Sylvia nisoria**	**Phylloscopus bonelli**	**Phylloscopus collybita**	**Phylloscopus sibilatrix**	**Phylloscopus trochilus**
Emberiza hortulana									
Emberiza caesia									
Passer moabiticus									
Passer hispaniolensis									
Lanius senator									
Lanius nubicus									
Lanius collurio									
Muscicapa striata									
Phylloscopus trochilus									
Phylloscopus sibilatrix									
Phylloscopus collybita									-0.462
Phylloscopus bonelli								**<u>0.717</u>**	0.431
Sylvia nisoria									
Sylvia melanocephala							**<u>0.721</u>**		
Sylvia hortensis						0.498			
Sylvia curruca									
Sylvia communis		**<u>0.717</u>**	0.516						
Sylvia borin									
Sylvia atricapilla	0.486	**0.542**		0.523			0.480		
Hippolais pallida			0.525						
Acrocephalus scirpaceus	**<u>0.747</u>**		0.503						
A. schoenobaenus	**0.567**			0.534			**<u>0.706</u>**		
Acrocephalus arundinaceus	0.445		**<u>0.719</u>**						0.488
Locustella luscinioides	**<u>0.729</u>**	**0.671**							
Oenanthe oenanthe									0.514
Oenanthe hispanica				*0.406*			0.517		
Phoenicurus phoenicurus									
Luscinia svecica				**0.580**			**0.585**		
Luscinia megarhynchos						0.467			
Luscinia luscinia					*0.445*				
Cercotrichas galactotes									
Anthus trivialis		0.526							
Jynx torquilla	*0.418*					0.481		0.548	
Coturnix coturnix	0.538			**0.615**					

Species	**Muscicapa striata**	**Lanius collurio**	**Lanius nubicus**	**Lanius senator**	**Passer hispaniolensis**	**Passer moabiticus**	**Emberiza caesia**	**Emberiza hortulana**
Emberiza hortulana								
Emberiza caesia								
Passer moabiticus								
Passer hispaniolensis							-0.484	
Lanius senator								0.482
Lanius nubicus								
Lanius collurio			**0.566**		*0.422*			
Muscicapa striata								
Phylloscopus trochilus								
Phylloscopus sibilatrix								
Phylloscopus collybita					0.576			
Phylloscopus bonelli				*0.415*				
Sylvia nisoria	**0.598**					0.579		
Sylvia melanocephala					0.484	0.525		0.578
Sylvia hortensis		**0.656**	0.479	*0.400*	*0.422*			
Sylvia curruca			**0.593**					
Sylvia communis		*0.405*						
Sylvia borin		*0.413*						0.497
Sylvia atricapilla								
Hippolais pallida				0.457				
Acrocephalus scirpaceus								
A. schoenobaenus		0.474	0.435		*0.406*			*0.408*
Acrocephalus arundinaceus		**0.662**		0.497				
Locustella luscinioides			*0.405*					
Oenanthe oenanthe		*0.416*	0.522					0.544
Oenanthe hispanica								
Phoenicurus phoenicurus							*0.414*	
Luscinia svecica					**0.729**			
Luscinia megarhynchos				0.473				
Luscinia luscinia						**0.572**		
Cercotrichas galactotes								
Anthus trivialis			**0.607**					
Jynx torquilla								
Coturnix coturnix		0.570						0.485

Table 3. Correlation between medians of all captures dates of 34 species in the spring in Eilat during 1984–2003. (Spearman's rank correlation **0.701**, $p < 0{,}001$; **0.542**, $p < 0.01$; 0.449, $p < 0.05$; *0.413*, $p < 0.1$)

Species	***Coturnix coturnix***	***Jynx torquilla***	***Anthus trivialis***	***Cercotrichas galactotes***	***Luscinia luscinia***	***Luscinia megarhynchos***	***Luscinia svecica***
Emberiza hortulana							
Emberiza caesia							
Passer moabiticus							
Passer hispaniolensis							
Lanius senator							
Lanius nubicus							
Lanius collurio							
Muscicapa striata							
Phylloscopus trochilus							
Phylloscopus sibilatrix							
Phylloscopus collybita							
Phylloscopus bonelli							
Sylvia nisoria							
Sylvia melanocephala							
Sylvia hortensis							
Sylvia curruca							
Sylvia communis							
Sylvia borin							
Sylvia atricapilla							
Hippolais pallida							
Acrocephalus scirpaceus							
A. schoenobaenus							
Acrocephalus arundinaceus							
Locustella luscinioides							
Oenanthe oenanthe							
Oenanthe hispanica							
Phoenicurus phoenicurus							
Luscinia svecica							
Luscinia megarhynchos							
Luscinia luscinia							
Cercotrichas galactotes							-0.589
Anthus trivialis				0.552	0.819		
Jynx torquilla				-0.652			
Coturnix coturnix							

Species	*Phoenicurus phoenicurus*	*Oenanthe hispanica*	*Oenanthe oenanthe*	*Locustella luscinioides*	*A. arundinaceus*	*A. schoenobaenus*	*Acrocephalus scirpaceus*	*Hippolais pallida*
Emberiza hortulana								
Emberiza caesia								
Passer moabiticus								
Passer hispaniolensis								
Lanius senator								
Lanius nubicus								
Lanius collurio								
Muscicapa striata								
Phylloscopus trochilus								
Phylloscopus sibilatrix								
Phylloscopus collybita								
Phylloscopus bonelli								
Sylvia nisoria								
Sylvia melanocephala								
Sylvia hortensis								
Sylvia curruca								
Sylvia communis								
Sylvia borin								
Sylvia atricapilla								
Hippolais pallida								
Acrocephalus scirpaceus								
A. schoenobaenus							0.454	
Acrocephalus arundinaceus						0.582		
Locustella luscinioides								
Oenanthe oenanthe				**0.814**				
Oenanthe hispanica			**0.937**				**0.750**	
Phoenicurus phoenicurus		0.973	**0.991**	*0.635*			*0.613*	
Luscinia svecica				*0.449*				
Luscinia megarhynchos				*-0.542*				
Luscinia luscinia	0.886		0.900					
Cercotrichas galactotes								
Anthus trivialis								
Jynx torquilla				*0.496*		0.549		
Coturnix coturnix								

Species	*Sylvia atricapilla*	*Sylvia borin*	*Sylvia communis*	*Sylvia curruca*	*Sylvia hortensis*	*Sylvia melanocephala*	*Sylvia nisoria*	*Phylloscopus bonelli*
Emberiza hortulana								
Emberiza caesia								
Passer moabiticus								
Passer hispaniolensis								
Lanius senator								
Lanius nubicus								
Lanius collurio								
Muscicapa striata								
Phylloscopus trochilus								
Phylloscopus sibilatrix								
Phylloscopus collybita								
Phylloscopus bonelli								
Sylvia nisoria								-0.851
Sylvia melanocephala								
Sylvia hortensis								*0.608*
Sylvia curruca								
Sylvia communis				**0.634**				
Sylvia borin							0.881	-0.596
Sylvia atricapilla			0.512	0.438				
Hippolais pallida	0.505							
Acrocephalus scirpaceus	**0.577**							
A. schoenobaenus								
Acrocephalus arundinaceus								
Locustella luscinioides	*0.558*	*-0.450*	0.525	**0.746**				
Oenanthe oenanthe			**0.761**	*0.614*				
Oenanthe hispanica	**0.918**	-0.667	*0.718*					0.743
Phoenicurus phoenicurus	**0.929**	*-0.586*		*0.647*	0.723			**0.750**
Luscinia svecica		-0.487						
Luscinia megarhynchos								
Luscinia luscinia	0.778	0.790					*0.750*	
Cercotrichas galactotes							*0.727*	
Anthus trivialis								
Jynx torquilla								
Coturnix coturnix				*0.540*	*0.648*			

Species	*Phylloscopus collybita*	*Phylloscopus sibilatrix*	*Phylloscopus trochilus*	*Muscicapa striata*	*Lanius collurio*	*Lanius nubicus*	*Lanius senator*	*Passer hispaniolensis*
Emberiza hortulana								
Emberiza caesia								
Passer moabiticus								
Passer hispaniolensis								
Lanius senator								
Lanius nubicus								
Lanius collurio								
Muscicapa striata								
Phylloscopus trochilus					*0.754*			
Phylloscopus sibilatrix								
Phylloscopus collybita								
Phylloscopus bonelli				**-0.899**				
Sylvia nisoria								
Sylvia melanocephala	0.570							
Sylvia hortensis					-0.900			*0.582*
Sylvia curruca							0.575	
Sylvia communis	0.487						**0.761**	
Sylvia borin	-0.493							
Sylvia atricapilla								
Hippolais pallida								
Acrocephalus scirpaceus						0.557		
A. schoenobaenus							0.562	
Acrocephalus arundinaceus			**0.713**					
Locustella luscinioides	*0.473*						0.659	
Oenanthe oenanthe						0.886	**0.723**	
Oenanthe hispanica						0.798	**0.791**	
Phoenicurus phoenicurus						**0.836**	*0.693*	
Luscinia svecica								0.459
Luscinia megarhynchos								
Luscinia luscinia								
Cercotrichas galactotes								
Anthus trivialis								
Jynx torquilla								
Coturnix coturnix								*0.522*

Species	*Passer moabiticus*	*Emberiza caesia*	*Emberiza hortulana*
Emberiza hortulana			
Emberiza caesia			
Passer moabiticus			
Passer hispaniolensis			
Lanius senator			
Lanius nubicus			
Lanius collurio			
Muscicapa striata			
Phylloscopus trochilus			
Phylloscopus sibilatrix			
Phylloscopus collybita			
Phylloscopus bonelli			
Sylvia nisoria			
Sylvia melanocephala			
Sylvia hortensis			
Sylvia curruca			
Sylvia communis			
Sylvia borin			
Sylvia atricapilla			
Hippolais pallida		**-0.761**	
Acrocephalus scirpaceus			
A. schoenobaenus			
Acrocephalus arundinaceus			
Locustella luscinioides			
Oenanthe oenanthe			
Oenanthe hispanica			
Phoenicurus phoenicurus			
Luscinia svecica			
Luscinia megarhynchos			
Luscinia luscinia			
Cercotrichas galactotes			
Anthus trivialis			
Jynx torquilla		0.697	
Coturnix coturnix			

The first species to arrive in the spring are Quail, Reed Warbler (*A. scirpaceus*), Savi's Warbler (*Locustella lusciniodes*), Blackcap (*S. atricapilla*), Common Whitethroat (*S. communis*), and Lesser Whitethroat (*S. curruca*). These species usually appear in Eilat in the second half of February (Table 1); their initial captures are positively and

Table 4. Mean of first capture in two consecutive decades – 1984–1993 and 1994–2003 (comparison by Mann-Whitney U test).

Species	1984–1993	1994–2003	Difference, days	*P*
Coturnix coturnix	29.2	24.2	6	0.150937
Jynx torquilla	13.3	10.3	3	0.324116
Anthus trivialis	21.3	26.3	-5	0.130583
Cercotrichas galactotes	11.4	10.4	1	0.4871
Luscinia luscinia	14.4	10.4	5	0.544293
Luscinia megarhynchos	24.3	22.3	2	0.939607
Luscinia svecica	19.2	29.1	21	**0.0010**
Phoenicurus phoenicurus	14.3	25.3	-11	0.161034
Oenanthe hispanica	10.3	20.3	-10	0.206919
Oenanthe oenanthe	15.3	18.3	-3	0.413402
Locustella luscinioides	24.2	1.3	-4	0.622787
Acrocephalus arundinaceus	3.4	31.3	3	0.676899
A. schoenobaenus	19.2	15.2	4	0.426839
Acrocephalus scirpaceus	25.2	27.2	-2	0.820265
Hippolais pallida	12.3	9.3	3	1
Sylvia atricapilla	7.3	26.2	9	0.343985
Sylvia borin	23.4	20.4	3	0.181392
Sylvia communis	23.2	2.3	-7	0.8
Sylvia curruca	24.2	26.2	-2	0.647795
Sylvia hortensis	25.3	16.3	8	0.37949
Sylvia melanocephala	19.2	10.2	9	0.121515
Sylvia nisoria	3.5	24.4	9	0.228487
Phylloscopus bonelli	11.3	11.3	0	0.703217
Phylloscopus collybita	16.2	6.2	10	0.110933
Phylloscopus sibilatrix	13.4	9.4	4	0.688823
Phylloscopus trochilus	23.3	28.3	-5	0.271235
Muscicapa striata	27.4	18.4	9	0.170445
Lanius collurio	26.4	18.4	8	0.191198
Lanius nubicus	21.3	21.3	0	0.733346
Lanius senator	12.3	11.3	1	0.964528
Passer hispaniolensis	22.2	31.1	22	**0.002471**
Passer moabiticus	22.2	14.2	8	0.229376
Emberiza caesia	11.3	19.3	-8	**0.02255**
Emberiza hortulana	28.3	26.3	2	0.279794

significantly correlated among themselves (Table 2). The second wave of migrants arrives in the second 10 days of March. The initial capture of Wryneck, Black-eared Wheatear (*Oenanthe hispanica*), Northern Wheatear (*0. oenanthe*), Bonelli's Warbler (*P. bonelli*), Olivaceous Warbler (*H. pallida*), Woodchat Shrike (*L. senator*), Cretzschmar's Bunting (*E.ceasia*) occurs almost simultaneously (Table 1). During the next 7–10 days, waves of Tree Pipit (A*nthus trivialis*), Redstart (*Phoenicurus phoenicurus*), Common Nightingale (*Luscinia megarhynchos*), Great Reed Warbler (*A. arundinaceus*), Orphean Warbler (*S. hortensis*), Willow Warbler (*P. trochilus*), Masked Shrike (*L. nubicus*), and Ortolan Bunting (*E. hortulana*) come through. In early April, mixed with the tail end of the third wave, Thrush Nightingale (*L. luscinia*), Rufous Bush Robin (*Cercotrichas galactotes*), Wood Warbler (*P. sibilatrix*), Garden Warbler (*S. borin*), Barred Warbler (*S. nisoria*), Spotted Flycatcher (*Muscicapa striata*), and Red-backed Shrike (*L. collurio*) constitute the last wave of initial arrivals at Eilat.

By correlation analyses, we found a strong and positive correlation among the medians of all species that arrive together (Table 3). However, there are significant negative correlations between the median date of spring migration among early migrants and those that migrate late (e.g., between the medians of spring migration of Garden Warbler and six early migrants).

In several species we found a significant correlation between initial capture dates in the spring and in the calendar years (Bluethroat, *L. svecica*, $r_s = -0.648$, $p = 0.002$; Orphean Warbler $r_s = -0.502$, $p = 0.0403$; Spanish Sparrow $r_s = -0.702$, $p = 0.0006$; Cretzschmar's Bunting $r_s = 0.6974$, $p = 0.0009$). In contrast, no such connection was found for Barred Warbler ($r_s = -0.391$, $p = 0.1203$), Spotted Flycatcher ($r_s = -0.398$ $p = 0.102$), Red-backed Shrike ($r_s = -0.419$, $p = 0.094$), and Dead Sea Sparrow ($r_s = -0.40124$, $p = 0.0989$). Further, we found a marked correlation between the medians of all capture dates in spring and in calendar years (Red-backed Shrike $r_s = -0.886$, $p = 0.01885$; Dead Sea Sparrow $r_s = -0.6946$, $p = 0.005$; Cretzschmar's Bunting $r_s = 0.6549$, $p = 0.0268$).

A comparison of mean data regarding initial capture dates during the two consecutive decades indicated that all 34 species arrived on average three days earlier from 1984–1993 than from 1994–2003 (17 vs 14 of March). However, the difference is not statistically significant (Mann-Whitney U Test, U= 563, Z= 0.184, $p = 0.854$).

Discussions

The beginning of spring migration for birds is controlled by the photoperiod or by means of special endogenous programs that are initiated in the breeding areas, and are specific for species that winter in the equatorial regions or further south (Gwinner 1996; Berthold 2001). Following this concept, many researchers believe that spring migration in Africa begins approximately at the same time, and that this is specific for each species, subspecies or separate population. Alerstam (1990) suggested that weather conditions determine the speed of spring migration, but not the timing of its

initiation. Sparks et al. (2001) and Hüppop and Hüppop (2003) found that weather conditions on the European continent determined strong interannual fluctuations in the timing of arrival of long-distance migrants in breeding areas.

To date, Eilat is the southernmost site for which there exists a long-term monitoring data set of spring migration phenology, and is closest to the wintering grounds. Of the 34 species chosen for analyses, the majority (24) were long-distance migrants from Africa to Europe and Asia, some (9) breed in the Mediterranean basin, and one, the Rufus Bush-Robin, is a summer visitor that breeds in the Eilat region and the Negev desert. The initial capture dates and median for many species varied considerably between years. The median date of spring migration (median of all captures) for some species also varied greatly between years (Table 1). Moreover, initial arrival dates and the median date of spring migration were very positively connected with each other, though the median dates of early migrants were very negatively associated with median dates of late migrants (Tables 2, 3). Assuming that birds do not stop over for longer periods in the desert, we infer that crossing the Sahara occurs on variable dates. It also suggests that the spring migration phenology at Eilat is strongly connected to extrinsic factors such as weather conditions in Africa or global climatic processes in the Northern hemisphere. The concomitant arrival of the same groups of species also suggests that weather influences the initiation of spring migration of those birds arriving at Eilat. A major weather pattern observed to have an effect on the medians of migration is known as the Hamsin. A Hamsin weather pattern consists of days (sometimes up to a week) of very hot, dry weather due to strong easterly winds occurring mostly in the spring. The Hamsin winds delay migration in late-migrating species such as the Garden and Barred Warbler and the Spotted Flycatcher (pers. obs.).

For several species of birds we found a connection between dates of initial capture and the calendar year. Some of these can be attributed to the influence of global warming on avian spring migration, as shown by several studies (Bairlein and Winkel 2001; Sokolov 2001; Sparks et al. 2001; Hüppop and Hüppop 2003; Butler 2003). Only the Orphean Warbler showed a strong positive correlation of initial capture with the calendar year, whereas the Barred Warbler and Grey Flycatcher displayed insignificant trends. The Dead Sea Sparrow and Red-Backed Shrike showed positive correlations of initial arrival date with the medians of spring migration.

Similar to long-term studies by Sokolov (2001; 43 years) and Butler (2003; 90 years), we concluded that it is imperative that the long-term ringing program at Eilat continues in such a way that the influence of environmental pressures on phenological trends of migratory birds will be evident in future decades.

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References

Alerstam T (1990) Bird Migration. Cambridge Univ. Press.

Bairlein F, Winkel W (2001) Birds and climate change. In: Lozan JL, Grabl H, Hupfer P (Eds) Climate of the 21st century: changes and risk. Hamburg. 278–282.

Barrett RT (2002) The phenology of spring bird migration to north Norway. Bird Study 49: 270–277.

Berthold P (2001) Bird Migration: a general survey, 2nd ed. Oxford University Press.

Butler C (2003) The disproportionate effect of global warming on the arrival dates of short-distance migratory birds in North America. Ibis. 145:484–495.

Gwinner E (1996) Circadian and circannual programmes in avian migration. J. Exp. Biol. 199: 39–48.

Hüppop O, Hüppop K (2003) North Atlantic oscillation and timing of spring migration in birds. Proc. R. Soc. Lond. B 270: 233–240.

Izhaki I, Maitav A (1998) Blackcaps *Sylvia atricapilla* stopping over at the desert edge; inter- and intra-sexual differences in spring and autumn migration. Ibis 140: 234–243.

Leshem Y, Yom-Tov Y (1996) The magnitude and timing of migration by soaring raptors, pelicans and storks over Israel. Ibis 138: 188–203.

Leshem Y, Yom-Tov Y (1998) Routes of migrating soaring birds. Ibis 140: 41–52.

Mason CF (1995) Long-term trends in the arrival dates of spring migrants. Bird Study 42: 182–189.

Morgan JH, Shirihai H (1997) Passerines and Passerine migration in Eilat. Int. Birdwatching Center Eilat Tech. Publ. Vol. 6. N 1.

Sokal RR, Rohlf FJ (1995) Biometry. 3rd ed. Freeman, New York.

Sokolov LV (2001) Climatic influence on year-to-year variation in timing of migration and breeding phenology in passerines on the Courish Spit. Ring 23 (1): 159–166.

Sokolov LV, Markovets MYu, Shapoval AP, Morozov YuG (1998) Long-term trends in the timing of spring migration of passerines on the Courish Spit of the Baltic Sea. Avian Ecol. Behav. 1: 1–21.

Sparks TH (1999) Phenology and the changing pattern of bird migration in Britain. Int. J. Biometeor. 42: 134–138.

Sparks TH, Roberts DR, Crick HQP (2001) What is the value of first arrival dates of spring migrants in phenology? Avian Ecol. Behav. 7: 75–85.

Sparks TH, Crick HQP, Dunn P, Sokolov LV (2003) Phenology of selected lifeforms: birds. In: Phenology: An integrative Environmental Science (M.D. Schwartz, Ed.). Kluwer Acad. Publishers.

Yosef R, Tryjanowski P (2002a) Avian species saturation at a long-term ringing station – a never-ending story? – J. Yamashina Inst. Ornithol. 50th Anniversary issue. 34: 89–95.

Yosef R, Tryjanowski P (2002b) Differences between the spring and autumn migration of the Red-becked Shrike *Lanius collurio*: record from the Eilat stopover (Israel). Acta Ornithologica 37: 85–90.

Yosef R, Tryjanowski P (2002c) Migratory Masked Shrikes *Lanius nubicus* staging at the desert edge: phenology, and sex- and age-related differences in body mass. The Ostrich 73:162–165.

Yosef R, Tryjanowski P (2002d) Differential spring migration of Ortolan Bunting *Emberiza hortulana* by sex and age at Eilat, Israel. Ornis fenn. 79: 173–180.

Yosef R, Tryjanowski P (2002e) Spring migration ecology of Cretzschmar's Bunting (*Emberiza caesia)* through Eilat, Israel. Israel Jour. of Zool. 48: 149–153.